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USSR Report

ENERGY

No. 55

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CONTENTS

ELECTRIC POWER

Kanev Pumped Storage Power Plant Described
(D. Dons'kyy; RADYANS'KA UKRAYINA, 12 Feb 81) 1

ENERGY CONSERVATION

Economy of Heat-Supplying Atomic Stations Assessed
(Viktor Alekseyevich Sidorenko Interview; NAUKA I ZHIZN, Jan 81) 4

FUELS

Detailed Exploration of Oil Reserves Viewed as Producers' Job
(V. Niz'yev; SOTSIALISTICHESKAYA INDUSTRIYA, 3 Feb 81) ... 17

Use of Volga District Shale as Fuel Urged
(F. Koval'skiy; SOTSIALISTICHESKAYA INDUSTRIYA, 11 Jan 81) 20

Recent Progress, Current Problems at Komi Oil, Gas Fields Told
(A. Kurkov; PRAVDA, 3 Feb 81) 22

Life of Oil-Recovery Equipment Between Repairs Must Be Lengthened
(A. A. Dzhavadyan, Ya. Ya. Shkadov; NEFTYANOYE KHOZYAYSTVO, No 1, 1981) 24

Future Tasks for Ukraine's Coal Mining Industry Described
(N. K. Grin'ko; UGOL' UKRAINY, Jan 81) 31

More Useful Analysis of Coal Enterprises' Wage Structure Urged
(A. G. Chirakh; UGOL' UKRAINY, Jan 81) 35

ELECTRIC POWER

KANEV PUMPED STORAGE POWER PLANT DESCRIBED

Kiev RADYANS'KA UKRAYINA in Ukrainian 12 Feb 81 p 7

[Article by D. Dons'kyy: "There Shall Be a Kanev Energy Giant"]

> [Text] A decision was made to build a pumped storage power plant [HAES] near the city of Kanev. Its power will exceed the combined energy power of the Kakhovka, Dneprodzerzhynsk, Kremenchug, Kanev and Kiev power plants.

The Kiev pumped storage power plant was the first in the Soviet Union. It has been constructed and is working well near the rayon center Vyshgorod. An unusually low building with a machine hall stands near the Kiev power plant dam at the foot of a picturesque hill rising almost 70 meters above Dnepr's level. There is a special artificial reservoir on the hill with pipes leading from it down a steep slope into the plant. This is the pumped storage power plant. Its main working force is water. It is pumped from the river to the top by reverse pump turbines and when the water goes down, the same units work as current generators. Thus the waterfall creates energy. The pumped storage power plant works four hours a day actively as an electric power plant, it accumulates water from the Dnepr for seven hours.

Today most "peak" loads are carried by thermal stations. Adapted to morning and evening hour splurges of energy use, they modify their work regime with difficulty. Fuel expenditures increase, equipment is worn out ahead of time and accident frequency rises. Large hydraulic power plants play an important role in solving this urgent problem. However, in the European region of the USSR, where the chief consumers of electrical energy are located, there is no place to build them, not even on the Dnepr. The Ukraine's main river has already been used for the construction of six power plants. Specialists see a solution to the problem in the construction of high maneuvering pumped storage power plants which, in contrast to basic thermal and atomic power plants, are able to handle sharp changes in work load.

As a result of the above, the CC CPSU project for the 26th Party Congress "Basic Directions for USSR economic and social development for 1981-1985 and the period up to 1990" anticipates the construction of pumped storage power plants in the European part of the country. Construction has started now on the Zagorsk power plant near Moscow, Kayshyadorsk in Lithuania and the Leningrad HAES. Power plants will be built on the Dnestr, southern Bug and other rivers where the areas surveyed have drops of above 100 meters.

There is an urgent need in our republic to find a place for a special half-peak pumped storage power plant which would become a promising and reliable helper to large thermal and atomic power plants in all instances. Engineers at the "Ukrhidroproekt" (Kharkov) found such an area in the Cherkassakaya Oblast on the right bank of the Dnepr near Kanev. This is where it was decided to build a pumped storage power plant of tremendous power capacity--3,600,000 kilowatts. It would be used for providing night relief for the Kiev thermal-electric centers, the Trypillya state regional electric power station, Chernobil atomic and Chigirin condensating electric power plants.

Details on this unique energy giant were given to the author by the chief engineer for the HAES project construction justification, S.H. Ahyeyev. He is an experienced specialist, a hydrotechnologist, former chief engineer for the Kanev power plant project, contributor to the creation of the Kremenchug and other hydro-electric power centers. Now Semen Heorhiyovych has settled in Kanev, where he is heading a group of work planners for this new, unusual facility of Ukrainian energetics.

The "mission" of these Kharkov friends to the famous city will last several years. Such is their work.

The reader already knows that water and a hill must be available for pumped storage power plant construction. Prior to saying firmly "the Kanev plant will be here," five possible locations were heatedly and thoroughly discussed at the "Ukrhidroproekt." Their choice fell upon the heights near Buchak village, ten kilometers higher than the Kanev range. The large plateau which rises more than 150 meters above the Knepr has a considerable natural depression. It seems that nature herself set aside this valley for the up-river reservoir of the power plant.

God himself started the HAES construction
But managed to create the valley only for effect,
To build a reservoir above.
There were no means or plan for more
How long will He be creating?

This humorous poem, in which the initial letters of each line spell out the word "Buchak" [poem written in Russian], was composed by S.H. Ahyeyev. Although he has no claims to its literary value, he affixed his authoritative signature firmly to the first volume of the technical-economical justifications for this unique construction. By covering ravines with enclosing embankments and a soil dam, a gigantic reservoir is created with a five square kilometer water surface area and a depth of more than 50 meters. Almost 90,000,000 "cubes" of water will be pumped here by pumps seven hours at night.

The pumped storage power plant building is placed at the foot of the Dnepr slope where waves from the Kanev sea splash. There are eighteen reverse turbines in the machine hall. There are eighteen reinforced concrete pipelines with steel revets between the power station and the top reservoir. The diameter of each--7.5 and 900 meters in length. To clarify these two figures--these pipes will carry five times more water than the Dnepr carries in the summer. Roaring streams will rush through these pipes with a striking force turning on generators 200,000 kilowatts each. One machine has the power of almost the whole Kiev HAES. There has been no similar plan up to now either in the Soviet Union or anywhere else in the world. Utilizing full capacity this unusual electrical plant will save almost 10 million tons of conditional fuel per year.

Construction work technology is resolved remarkably. Sandy soil removed with soil equipment and excavators from the reservoir for HAES foundation and other facilities will go for building the dam body and the enclosing embankments, and for filling up the ravines. (In all, almost 110 million cubic meters of soil will be moved about.) Top reservoir edge sections are reinforced with a protective layer of sand, monolithic reinforced concrete slabs and crushed stone. An inspection road will run along the dam ridge.

Any large or small construction project today is inevitably tied in to the requirements of laws for the protection of nature. The Kanev HAES will be situated in an area of little use. Construction plans provide for the support of ecological balance, protection of local animals and plants. The power plant itself is a very "clean" enterprise. The mechanical transfer of water from one reservoir into another will not affect the immediate environment.

Favorable conditions are developing for a small town which will rise in stories on a picturesque, sloping river bank. Thousands of HAES builders and operators will live there in complete present-day comfort. Compact, comfortable and green, it will become a worthy beautifier of the area around Shevchenko's historical city on the Dnepr.

This is how the additional energy gift will look. Its biography begins in the first year of the 11th Five-Year Plan. It starts with the CC CPSU Plan for the 26th Party Congress.

9443
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ENERGY CONSERVATION

ECONOMY OF HEAT-SUPPLYING ATOMIC STATIONS ASSESSED

Moscow NAUKA I ZHIZN' in Russian No 1, Jan 81 pp 50-57

[Interview with Prof Viktor Alekseyevich Sidorenko, doctor of technical sciences and department director at the Institute of Atomic Energy imeni I. V. Kurchatov, by S. Kipnis]

> [Text] More than a quarter century has gone by since that important day when, in the Soviet Union, the world's first atomic electric power station [AES] began producing commercial power. During this period of time, atomic electric power production, which has become a general trend in the use of nuclear power, has achieved great success. The continued growth of AES power output and the percentage increase in their contribution to the total production of electric power are noted in the 11th Five-Year Plan. This will make it possible to set up a more efficient fuel-energy balance for the country and to conserve such resources as oil and gas. Atomic electric power production, however, is not the only way to utilize the power of nuclear fission. A new trend has developed in recent years: atomic heat-supply, the extensive introduction of which should provide a more considerable impact on the conservation of scarce fuel supplies than that from atomic electric power stations.
>
> Our correspondent S. Kipnis asked one of the leading scientists in this area, Doctor of Technical Sciences and USSR State Prize laureate Professor Viktor Alekseyevich Sidorenko, department director of the Institute of Atomic Energy imeni I. V. Kurchatov, to reply to a number of questions regarding atomic heat-supply.

A Task of Particular Importance

[Question] In one of the articles published recently, the President of the USSR Academy of Sciences, Academician A. P. Aleksandrov, wrote: "The development and expansion in every possible way of the types of industrial processes which can be converted to atomic power resources is one of the most important practical problems facing our generation. With the advent of the feasibility of enploying nuclear-fission power, the first trend in its application has been determined--electric-power production. Even if all electric power stations, however, were converted to nuclear fuel, the impact would not be very considerable: the consumption of natural fuel would be reduced by only 20 percent, while the expenditure of oil and gas would be reduced even less--by only 10 percent, since approximately half of the electric power stations are coal-fired.

Thus, the time has come to think about other spheres of application for nuclear power. The generation of thermal power for industrial and heating uses and the inclusion of atomic power in metallurgy and the chemical industry are tasks of considerably greater scale than electric-power production. In the future, of course, mankind will be witness to the incursion of nuclear engineering into these areas."

It is commonly believed by the overwhelming majority of people that the basic job for the atom is the production of electric power, that is, the work done at atomic electric-power stations. For this reason, it is difficult to accept the assertion that nuclear energy has a job on an even larger scale.

[Answer] Nevertheless, it is true. Thermal electric power stations are far from being the largest consumers of fuel. It is enough to say, for example, that one and a half times as much fuel is used for the production of hot water and steam (low-temperature heat) for the needs of cities and industry, a considerable portion of the heat being generated by small, low-efficiency units which burn the most valuable types of fuel--oil and gas.

It is clear that the application of atomic power to obtain low-temperature heat should provide a huge impact.

We will not speak of supplying industry, primarily metallurgical and chemical, with high-temperature heat (800-1,000°C and higher). This broad topic of discussion is separate and independent. I will note only that the greatest hopes of many sectors of industry are also involved with the application of atomic power to obtain high-temperature heat.

On a Country-wide Scale

[Question] Just what are the requirements of the housing and utilities sector and of industry for low-temperature heat?

[Answer] First of all, let me specify that water at a maximum temperature of 150°C (depending primarily, of course, upon the season) is the main heat-transfer agent for the heating and hot-water supply to our cities. Regarding industrial heat-supply, hot water (about 30 percent) and saturated steam (about 70 percent) at pressures of 3 to 40 atm (0.3 to 4 megapascals--MPa) are used as heat-transfer agents. The range of consumers of low-temperature water in industry is very broad. In fact, the overwhelming majority of industrial processes cannot proceed without hot water or steam, which are needed for preheating the working environment.

Let us now discuss the extent of low-temperature heat consumption in our country.

The consumption of low-temperature heat is in fact enormous. A city with a population of 300,000 to 400,000, for example, requires, on the average, 800-1,000 Gcal/h

(1 Gcal is 1 billion calories) for domestic purposes. In order to obtain this much heat (considering the unavoidable losses), 300 to 400 t of fuel oil would have to be burned hourly.

It is assumed that in the near future (in 15-20 years) the annual consumption of low-temperature heat in the USSR (still referred to as low-potential heat) will reach a very impressive figure--6 billion Gcal. In order to generate such a quantity of heat, we would have to burn, for example, 600 million tons of oil, that is, practically our entire annual yield. Consider also that this would be only under conditions of 100-percent utilization of its thermal content which, in actuality, of course, does not happen.

I will emphasize again that about 30-40 percent of all types of fuel are expended just for the production of hot water and industrial steam.

An Optimum Solution

[Question] How does the application of atomic power for heat-supply differ from the traditional power-production scheme at atomic power stations?

[Answer] Let us begin not with the differences between these two processes but with their similarities. An atomic reactor is used as the heat producer in both cases. I will remind you that a controlled chain reaction of the splitting of nuclei, for example, of U-235, takes place in the reactor's core. The fission fragments formed during this process fly about at great velocities. When they decelerate, all their kinetic energy is converted into heat which is removed by the heat-transfer agent circulating through the core in order to cool it. There can be various arrangements for the subsequent use of this heat. It can either be used to heat water in a heat exchanger, circulating in a second circuit, and turn it into steam, or it can be used directly in the reactor itself to superheat water and obtain steam with the necessary parameters.

In order to understand the specific nature of the process whereby heat is produced in an atomic reactor, we will dwell on certain features of a nuclear power source.

In the first place, we will note that such a power source is economically profitable, as is shown by all experience acquired in perfecting nuclear-power engineering, only when the unit outputs are rather large. For this reason, I will here note that when we speak of urban domestic heat-supply, the term "atomic boiler plant" often used in this case must, in a certain sense, be looked upon as very arbitrary. In fact, we can use the words "boiler plant" to refer to rather small power sources, thereby bringing about an unintentional association with district or home boiler plants. Based on economic requirements, an atomic heat source cannot be so small in scale.

It must be a sufficiently large station with atomic reactors having an overall output of 1,000 MW (for considerations of redundancy, the station is made up of two units of 500 MW each). Such a station will be able to provide heat for a city of 300,000 to 400,000 people.

In order to avoid ambiguities which arise with the use of the term "boiler plant," we have commonly adopted another name: the heat-supplying atomic station--AST. Henceforth, this is how we will refer to it.

A second essential feature of an atomic reactor is its sensitivity to the level of temperatures developed within it. It is this level which to a considerable degree determines the selection of the most suitable technical solutions for the use of nuclear fuel for heat-supply.

Let us recall that centralized heat-supply has become a characteristic feature of Soviet thermal-power engineering. This has led to our extensive enlargement of branching heating systems. For many years now, all new cities and new housing tracts have been developed on the basis of this centralized heat-supply. Because of this, it also became feasible to arrive in an intelligent manner at the selection of the method of heat-supply, based on scientific and technical organization.

Owing to considerations regarding the optimization of the thermal-power cycle, it follows that the simultaneous generation of thermal and electric power has the greatest economic impact. This is why heat-and-electric power stations have become a basic strategic direction in the development of heat-supply sources.

It would be perfectly natural in converting to a new type of fuel--nuclear--to turn to a similar solution, that is, to the construction of atomic heat-and-electric power stations. Technological history, however, testifies to the fact that the specific characteristics of this new source of power always entail some other optimal solutions.

[Question] Surely the history of atomic power development has confirmed this assumption?

[Answer] Yes, of course. I will cite an example which concerns the selection of steam parameters for atomic electric power stations.

Up until the time atomic electric power stations began to be developed, the basic direction for improving the power cycle in traditional thermal electric power stations--the superheating of steam--had been determined with sufficient precision. This, in turn, led to the creation of units with supercritical parameters. When it came time to select the optimum version of the steam cycle for atomic electric power stations, we settled on saturated steam and not superheated, although this was, and I emphasize, very unusual for classical thermal-power engineering. This branch of engineering had expended great efforts in order to achieve a cycle using superheated steam amd sought to further increase its parameters.

Why, then, have the designers of atomic electric power stations adopted such a solution? On one hand, in the transition from the saturated-steam state to the superheated, high temperatures, naturally, are necessary. The steam's heat content increases, although this increase is relatively small in comparison with the heat content accumulated by the steam as a result of boiling the water. On the other hand, the design features of electric power installations, their reliability of operation and the savings in utilizing nuclear fuel depend greatly upon the level of temperatures that we wish to achieve in the atomic reactor. The utilization of higher temperatures forces us to use materials that are more heat-resistant. This, as a rule, leads to a less economical expenditure of neutrons which originate in the fission process (the absorption of neutrons increases). All of this entails a series of reductions in the economic indicators for the utilization of nuclear fuel and an increase in the cost of the installation itself.

If we compare all these expenses with the advantages provided by the superheating of steam under AES conditions, the comparison proves not to be in favor of superheating. In fact, it is precisely in this case that the characteristics of a new thermal unit--the atomic reactor--become apparent. Technology that was obsolete for traditional power engineering using saturated steam of medium parameters proved to be optimal for today's atomic electric power stations. This, of course, is based chiefly on the materials that are available. In this case, the efficiency of the thermal cycle still remains at a rather modest level--30 to 40 percent.

Three Methods

[Question] The example which you cited reveals the logic behind the selection of steam parameters for AES's and it is obvious that it could also serve as a reply to the question why the atomic reactor still has not found application in obtaining high-temperature heat. When new materials necessary for the efficient operation of high-temperature reactors are created, it is certainly likely that all the problems hindering not only heat-supply but also the utilization of such reactors in metallurgy and the chemical industry will subside.

[Answer] Absolutely true. Here we have arrived at the central issue: how to utilize an atomic reactor most efficiently for heat supply, considering all its peculiarities which we have been discussing.

One can conceive of three methods of centralized heat-supply from an atomic-power source.

In the first place, there is the reiteration of the method which is traditional for our power engineers--the simultaneous generation of electric power and heat with the help of a heat-and-electric power station (TETs). In our case, this will be an atomic heat-and-electric power station (ATETs). Here the working fluid is steam. Before it gives off its heat to the heat-supply network, it first depletes its potential in the turbine in order to generate electric power. Basically, this determines the thermodynamic efficiency of such a combined method, that is, the high efficiency of the heat cycle.

Another method which can be conceived of is the following: heat going to the consumer is obtained not from steam in the steam-turbine cycle, but directly from the heat extracted from the primary coolant in the atomic reactor. Thus, there are two independent heat flows at the edge of the reactor: one is only for obtaining electric power, the other for heat-supply.

If we divide the heat source itself, we derive a third method: two autonomous working reactors independent of one another. One is for the production of electric power (an atomic electric power plant), while the other is used specially for heat-supply.

This is the single-purpose atomic heat-supply station, which generates only heat.

It turns out that, for purposes of heat supply under certain conditions (we will speak of these later), it is more expedient to build not the dual-purpose station--the ATETs--but a single purpose station--an AST. How can this be explained?

In the case of atomic heat-and-electric power stations, we are forced to stop at the same level of steam parameters used for atomic electric power stations. The utilization of considerably lower temperatures than in thermal-power engineering (which is stipulated, as we have said, by the characteristics of atomic reactors) undermines the economical basis of the dual-purpose utilization of heat. In fact, the traditional TETs is based on the superheated-steam cycle. Some portion of the steam bled from the turbine to heat water in a boiler for heat-supply has already used a considerable portion of its potential to generate electric power. The saturated steam of medium parameters used at an ATETs has a smaller initial reserve of energy. For this reason, the quantity of electric power obtained with it is also less.

The overall assumption regarding the theoretical profitability of combined generation in a single heat-and-power unit remains valid, of course, but when we compare the ATETs with a fossil-fuel fired TETs, the advantage today is with the latter.

The Chief Criterion--Efficiency

[Question] If we adopt a separate-generation scheme with electric power produced at an AES and heat at an AST, will we not lose in the final analysis? Is not the efficiency of an atomic electric power station due to the fact that, although much heat is lost in the turbine condensers, it is always less than at an ATETs?

[Answer] In order to evaluate the overall efficiency of this or that method or to compare them with respect to some economic indicators, it is not enough to rely exclusively on the efficiency figure. It in fact characterizes only the thermodynamic efficiency of the cycle. We need to select a more general economic indicator, one which will consider not only the unit consumption of fuel for the generation of an end-product form of energy but also other components.

Just what are these other components? First of all comes the capital outlay for the construction of the power source itself. This expenditure can prove to be considerably or, at any rate, noticeably different for these versions. In particular, due to the fact that an ATETs has the same reactor parameters as an AES but must be somewhat more complicated so that it can provide heat in addition to electric power, it will be somewhat more expensive than an AES with respect to specific indicators. On the other hand, owing to its specific characteristics (operation at lower temperatures), an AES will be cheaper than an ATETs with regard to specific indicators for capital outlay. An apparent opportunity to compare the different versions of heat-supply organization has already emerged: the less expensive AST and the average-cost AES or the higher-cost ATETs, which provides the best cycle efficiency, that is, the greatest utilization of fuel.

One should consider one more technical feature of the ATETs which makes its considerable contribution to comparing the variants. We are speaking here of the expenditures for the construction of a system to deliver heat from the power source to the consumer.

In accordance with public health standards, atomic electric power stations in practice are situated not less than 20 km from large population centers. The necessity for constructing additional dozens of kilometers of lines increases, of course, the expenditures for heat-supply from an ATETs.

At the modern level of know-how and the development of technology, we are in a position to fulfill all necessary health requirements when using any atomic power source, any degree of thermal or power stress in the core or any other parameters. Naturally, it all comes down to the size of the expenditure. In this case, a power source with lower temperature levels and lower stresses in the core requires less expensive technical solutions. Therefore, in the case of the AST, we can use sensible, economically justified technological means which make it possible to insure reliably against the most unlikely internal and external damage. Consequently, it becomes possible to move the atomic heat-supply source directly to the population center. As a result, thermal lines are shortened, thereby influencing yet another component of the economic expenditures.

Up to now we have paid attention to the expenditure of capital for the heat lines. In fact, they "eat up" not only money but land as well. Therefore, difficulties involved with the apportionment of land for laying the lines can prove to be no less important a factor than the simple expenditure for these heat lines.

In a scientific situation, a factor such as the proportions of electricity and heat being supplied to a given region can also prove to be important. According to the specific nature of power-supply which has taken shape in previous years, a region can experience, for example, an acute shortage of thermal power while being well supplied with electric power. Under these conditions, the construction of a dual-purpose station, an ATETs in particular, will result in the excess electric power being transmitted someplace else. This also reduces the cost of such a method of heat-supply.

[Question] What do the calculations of the efficiency of different versions and their comparison tell us?

[Answer] All the technical and economic studies which take into consideration the specific nature of power consumption by various parts of our country, the supply of power resources to these areas and many other factors testify conclusively to the fact that there are areas and regions where the application of both AST's and ATETs's in the next decade is practicable and where atomic heat-supply must be developed using the best possible method. This is particularly so in the European portion of the USSR.

The First Step

[Question] The atomic power industry uses various types of reactors, and each type of reactor entails corresponding design solutions in the entire remaining portion of the power installation. What type of reactor have you decided to use at AST's?

[Answer] It would be wrong to maintain that one particular type of reactor is suitable for single-purpose heat-supply. Theoretically, this problem can be solved using various types of reactors. Having considered the practicability of various types of reactors and the accumulated experience of their industrial manufacture and operation, we have determined that a shell-type water-moderated water-cooled reactor satisfies the entire set of problems in the best possible way. Fuel for the reactor is used in the form of fuel element containing uranium dioxide in a zirconium jacket. The reactor core is a bank of fuel elements assembled in a rigid grid located within the reactor shell. Movement of the coolant through the reactor core is provided for within the shell.

At atomic electric power stations, such a reactor operates according to a double-flow arrangement: the coolant transmits heat to the water in a second circuit in an intermediate heat-exchanger. In order to exclude even the most unlikely possibility of radioactive products making their way to the consumer, we have gone to a three-circuit arrangement for the construction of atomic heat-supply sources. This means that an intermediate circuit is built between the primary coolant circuit and the supply-water circuit. This is another of the technical solutions directed at satisfying the necessary health requirements.

[Question] Speaking of the main features of an atomic power installation, you mentioned first of all that it can be efficient only when the unit output is sufficiently great. You named 1,000 MW as the optimum value. Does this close the door to the use of atomic power for the generation of low-temperature heat under conditions when there are not such large consumers?

[Answer] No, it does not close the door. Under these conditions, however, where the extent of consumption is considerably less or even when there is an independent demand for heat, the approach for selecting the type of reactor will be different as well as the criteria for determining its technical and economic efficiency.

Today, for example, studies are being done on the utilization of reactors with high boiling-point organic coolants. These reactors have outputs of as low as 100 MW and are used for remote areas--the Far North, for example. There atomic heat-supply at even low levels is economically expedient, for it must be compared with the considerably more expensive fuel that has to be used in the alternate versions.

[Question] Obviously, this is an appropriate time to recall the Bilibinskaya ATETs, commissioned in 1974 in remote Siberia, in the settlement of Bilibino in Magadanskaya Oblast. Could we rightfully consider it to be a pioneer of atomic heat-supply?

[Answer] The Bilibinskaya ATETs is an example of the utilization of another kind of reactor, the channel-type uranium-graphite reactor. Together with water-modulated water-cooled shell-type reactors, they serve as the basis of development of our atomic power industry.[1] The Bilibinskaya ATETs is a dual-purpose station: it develops electric power and heat for domestic needs. It really is the first such atomic heat-supply source. Despite its small output (four units of 12-MW capacity each), the Bilibinskaya ATETs proved to be economically efficient for its own purposes under the conditions found in the Far North. The specific design characteristics of the channel-type reactor facilitated the task of transporting it to such a remote area.

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[1] See the article "The Atomic Hercules", NAUKA I ZHIZN' No 11, 1980.

[Question] Returning to the issue of large-scale heat-supply, we would like to find out how all these ideas which you have been talking about are put into practice in the specific design of the water-modulated water-cooled reactor selected as the basic reactor for AST's.

Reliability

[Answer] Once again I will emphasize that the chief condition determining all future solutions is the maximum possible degree of reactor reliability and the fulfillment of the strictest public health requirements. Simplicity of construction is the key to the solution of these problems. On one hand, simplicity of construction by itself already does predetermine to a considerable degree the reliability of the reactor as a source of energy. On the other hand, it opens the way to an economical solution to many other important questions.

The potential for simplifying the design of a reactor lies in the very conception for its utilization: only the generation of low-potential heat. I will remind you that a single-purpose reactor operates at considerably lower temperatures than an electric-power reactor. Besides this, the degree of thermal stress in the core comes out considerably lower. Such light-duty operating conditions make it possible to do without the forced movement of the coolant in the first circuit, that is, through the reactor core. In that case, one no longer needs the circulating pumps, their power-supply systems and other auxiliary equipment whose purpose is to insure the reliable operation of all these mechanisms, instruments and devices.

[Question] What forces the water to circulate through the reactor core if there are no pumps?

[Answer] The density of the hot water exiting the upper portion of the reactor is less than the density of water cooling in the heat exchanger (where it transmits a portion of its heat to water in the other circuit). Owing to this difference in the densities, the natural movement of water from bottom to top takes place without outside help.

In the first place, the transition to natural circulation makes it possible, as I said, to get by without mechanisms, the lack of which by itself increases the installation's reliability and simplifies maintenance. In the second place, the independence of natural circulation from external power sources excludes any type of damage which could occur to the power-supply system.

The features of a nuclear power source designed only to obtain heat become obvious here. It is as if they are drawn together into a single complex. Moving toward a reduced level of energy stresses in the reactor we thereby achieve the potential to simplify the design. We can do away with the whole complex and very cumbersome system of forced cooling.

This solution has opened the way for the next important step.

Once Again--Reliability

The main source of any kind of damage to the equipment at an AES is usually associated with the branching system of auxiliary pipes which provide for the operation of the reactor installation. For this reason, wishing to reduce the potential accident rate and thereby increase reliability, we seek to "exterminate" this secondary cobweb of pipes. So, having done away with the forced circulation, we thereby facilitated the solution to the problem. The external circulating network can be removed and natural circulation established through a heat-exchanger once we have located it within the reactor shell.

Thus, owing to the design solutions adopted, we succeed in realizing an integrated configuration for the reactor. With such an arrangement, only the pipes of the second, intermediate circuit and the mechanisms for controlling the regulation and shielding systems need to be run outside the shell of the reactor. From this second circuit, the heat will be transmitted further on into the thermal network.

[Question] What about the dimensions of such a reactor? Are not the dimensions of the shell for a water-modulated water-cooled reactor large enough already? For example, the diameter of the shell for a 440-MW unit reaches 4 m while its height achieves about 20 m.

[Answer] Of course, the integrated configuration leads to a certain increase in shell dimensions. The manufacture of such shells, however, does not become too difficult a production problem. Again, this is related to the fact that the generation of low-temperature heat has made it possible to reduce the pressure within the shell by a factor of 10--from 150 to 160 atm (15 to 16 MPa) to 15 atm, 20 atm maximum (1.5 to 2.0 MPa). This means that the thickness of the shell wall does not have to be 150-200 mm as in the case of high-output power reactors, but only 30-40 mm. Because of this, the manufacturing technology has been greatly simplified.

The diameter of the shell for a 500-MW reactor--two of these very units make up a 1,000-MW AST--does not exceed 6 m. Although this exceeds the allowable limits for railroad dimensions (about 4.5 m), there are nevertheless no special difficulties arising from transportation. Thanks to the lesser thickness of the wall, the mass of the reactor turns out not to be very great and the reactor can be shipped by motor transport or by water.

Let us return to the design features of an AST reactor.

The natural circulation within the shell and the integrated configuration make it easy enough to take yet another step toward increasing AST reliability.

One More Time On Reliability

[Question] You rather frequently--and this is entirely natural--return to the problem of reliability. Just what criteria guide the evaluation of reliability?

[Answer] A break in the largest-diameter pipe of the first or second circuit is usually considered as the maximum damage to an AES due to internal technical reasons. Based on this, the station is provided with all the necessary technical means. These facilities are capable of neutralizing damage and bringing under control all possible results of such damage.

Failures of the reactor shell or other equipment typical for an AES are not considered, since it is believed that these are extremely unlikely occurrences.

One particular feature of AST operations--its immediate proximity to the city--compels us to consider even these extremely rare accidents. For this, we must create equipment capable of insuring the required health conditions for AST operation not only when pipelines fail but also when there is damage to the reactor shells.

The features of the AST reactor (the use of natural circulation, the integrated configuration as well as the low pressure within the shell) make it possible to solve this problem at a level of acceptable expense. It is just a matter of creating a sufficiently simple design--a second, safety shell which would not exclude the feasibility of inspecting the main supporting shell. It would in no way diminish our requirements for its reliability as a chief element in the installation and would make it possible in case of the most extreme, unforeseen breach to contain fully within its own volume the entire insides of the reactor and all the coolant containing the radioactive substances.

I will give you a typical scenario for such an extreme occurrence.

With a breach of the main shell, the internal volume, now occupied by the coolant, increases somewhat and there is a corresponding drop in pressure of approximately 30 percent. Although the water level drops, it will encompass the entire core area as before and will insure its cooling. Owing to such close correspondence between the characteristics of the operational and protective equipment, reliable cooling of the core is insured.

From the Reactor to the Consumer

[Question] How is an AST with reactors of such design constructed and how does it operate?

[Answer] I think that the answer to the question just posed is largely provided by the flowsheet depicted in the colored insert [not included]. For this reason, I will limit myself to a few general observations.

An atomic heat-supplying station consists of a reactor, an intermediate coolant-circulating network and circuit heat-exchangers. All of this is housed in a building, the arrangement of the equipment and the design of the building being created in such a way as to protect the reactor installation as far as possible from external influences, even the most unlikely. The compact nature of the reactor makes it possible to accomplish all of this with the aid of rather moderate technical means.

The reactor core is made up of holders in which are installed the fuel elements containing the nuclear fuel in the form of uranium dioxide enriched to approximately 2 percent with U-235.

It is assumed that the nuclear fuel will be recharged once every two years with approximately one-third of the total number of fuel elements being replaced. Thus, a full charge of nuclear fuel is enough for 6 years of operation.

The core is situated in the welded cylindrical reactor shell which for an output of 500 MW possesses a diameter of approximately 6 m and a height of 15 m. Bundles of pipes for the three groups of heat-exchangers in the intermediate circuit are installed within the shell along its circumference, somewhat higher than the core. The water passing through the core rises along a cylindrical column--a space over the core filled by the coolant--and flows from above into the heat-exchangers. Here it is cooled on the external surfaces of pipes, flows downward and again, farther down, flows into the core area. Thus, the circulating network of the primary coolant is completed.

In order to improve the natural circulation--to increase the difference in densities between the ascending and descending fluids--it is sound practice to bring it to boiling and create a slight steam-content in it. As a result, a steam blanket is created over the water at the level of the heat-exchangers in the intermediate circuit. This small amount of steam formed when the water passes through the core condenses on the upper portion of the heat exchangers.

[Question] You mentioned that these groups of heat-exchangers are installed along the internal circumference of the shell. What is the sense of such a design decision?

[Answer] All of this has been done out of the same considerations for increasing reactor reliability. With this kind of redundancy, the reactor can continue operating at a reduced power level in case any of the independent loops in the reactor's second unit fails.

Let me mention one more design feature of these circuit loops. The circulation in these loops of the water that removes heat from the reactor is accomplished with the help of pumps during normal operation. If these pumps stop, let us say, because of troubles in the electric power supply or some other failure in an external system, nothing dangerous will occur. The reactor can shut down fast enough, and its cooling will be accomplished through the natural circulation of water in both the first and second circuits. This also is one of the measures insuring reliable cooling of the reactor in any situation.

A Ponderable Contribution

[Question] When and where will an AST with such reactors be built? What are the future prospects for the development of atomic heat-supply?

[Answer] The construction of two pilot AST's has already begun: one near Gor'kiy, the other near Voronezh. Each of them is a two-unit station with two 500-MW reactors, that is, with a total output of 1,000 MW. The construction sites are located outside city limits at a distance of 1.5 to 2 km. These AST's will provide heat to the districts of Gor'kiy and Voronezh, numbering approximately 300,000 to 400,000 inhabitants each. It is projected that these stations will join those already operating in a few years.

Speaking of the prospects for atomic heat-supply, I would like to direct your attention to one more essential characteristic of AST's. Their parameters and operating modes are designed in such a way that the stations enter the existing networks as auxiliary heat sources. The creation of such new, powerful, centralized sources makes it possible to dismantle obsolete installations operating on fossil fuels and use stations that are small but sufficiently technically ideal to operate on the peak loads that arise most often during the cold season. The AST's themselves will take on the basic portion of the load.

With respect to controllability, the AST is a very flexible unit which imposes no special requirements on the control of thermal networks with respect to regulating the distribution of heat. This is very important. In principle, the AST can also cover peak loads. For an atomic station, however, just as for any capital-intensive equipment (capital investments are large but the fuel component is small), the most economical operational mode is the one that provides the maximum possible level of steady power, that is, base-load operation.

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FUELS

DETAILED EXPLORATION OF OIL RESERVES VIEWED AS PRODUCERS' JOB

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 3 Feb 81 p 2

[Article by V. Niz'yev, Deputy RSFSR Minister of Geology: "The Strategy of Exploration"]

[Text] The CPSU Central Committee's draft for the 26th party congress calls for speeded up promotion of operations for geological study of the country and an increase in explored reserves of mineral raw-material resources, primarily fuel and power resources. To a great extent, successful solution of this important national economic task depends upon an improvement in planning and in organizing the whole geological exploration process, whose final purpose is the discovery and exploration of new deposits of useful minerals.

As far as oil and gas are concerned, a "distribution of roles" between geologists and the producing industries has existed for a long time. The geologists prospect for and explore underground stores in new, poorly studied, promising regions. The producers make detailed exploration of previously discovered fields and deposits and do prospecting work in old regions. Such a division of functions is dictated by practical considerations. For the basic task of the geologists is to establish a reliable raw-materials base for development of the oil and gas industry for many years ahead, a backlog of prospected resources for the future.

However, in practice everything seems to be different. USSR Ministry of Geology organizations are doing the major portion of the total amount of deep exploratory drilling. At the same time, the Ministry of Petroleum Industry has followed the policy of reducing exploration work. In 1970 exploratory drilling by oilfield workers was 32 percent of the total penetration of deep holes. And last year the share was reduced to 13 percent. This tendency is demonstrated still more graphically in the land of the country's oil and gas recovery base--West Siberia. Exploratory drilling here is less than 1 percent of the total meterage of Glavtyumenneftegaz [Main Administration of the Oil and Gas Industry of Tyumenskaya Oblast] of Minnefteprom [Ministry of Petroleum Industry]. But then Glavtyumengeologiya [Main Administration for Geology in Tyumenskaya Oblast] drills many hundreds of thousands of meters of exploratory hole in areas of West Siberia that have been studied geologically and have been basically developed.

Why have oilfield workers lost interest in exploration? The answer is simple: the current system for planning geological exploration prompts them to do this. USSR Gosplan plans the main growth in recoverable oil and gas reserves (more than

80 percent) for USSR Ministry of Geology organizations. And the rest is the share of the recovering industries, which, as they say, does not count.

What has this situation led to? Primarily to the fact that USSR Mingeo [Ministry of Geology] subunits, in carrying out extremely strenuous tasks to increase recoverable reserves, naturally aim their main labor, material and equipment resources at this portion of the work. There are not enough personnel and funds for an outracing promotion of regional geologico-geophysical and prospecting operations in new regions. Is it surprising that in such a situation the geologists have not always been motivated to expand prospecting work, while, in striving to carry out the plan for growth of reserves of high recoverable categories, they have been unjustifiably compelled to keep their productive capacity at already discovered fields for long periods?

In this connection, it seems to us that USSR Gosplan and USSR Ministry of Geology should, while planning growth of recoverable reserves, establish tasks for geologists about amounts of exploratory drilling and growth of promising oil and gas reserves (category C_2). With the introduction of such a system of planning, USSR Mingeo geological explorers will show greater interest in fulfilling their basic mission of insuring a reliable backlog of prospected reserves for the long term.

Geological prospecting underground is a process that is extremely complicated, prolonged and expensive. Many specialists and scientists, in our view, correctly consider that USSR Mingeo organizations should undertake four of the five main steps: regional study, preparation of areas for deep exploration, prospecting drilling, and industrial evaluation of discovered fields. But the concluding stage--the detailed exploration of fields and preparation thereof for exploitation--should, as a rule, be carried out by the producing ministries.

/This means that USSR Ministry of Geology should plan, not the recoverable category of reserves ($B + C_1$) but the reserves of lower categories ($C_1 + C_2$). It is natural that, in so doing, USSR Gosplan should plan that the producing industries do the detailed exploration of oil and gas fields, with a corresponding growth of reserves of the recoverable categories [in boldface]/

What will realization of this proposal yield? It will enable the periods for preparing geological reserves for industry's fuel and power resources for development to be greatly shortened. The producing industries' forces will be able to make the final detailed exploration of the fields during the industrial-test stage of development, basically operational drilling, which is must less capital intensive. It must be considered here that once a field is accepted for development, a meter of operational penetration costs one-third that of a meter of exploratory penetration.

The main advantage consists in the fact that the geologists' hands will, figuratively speaking, be untied for more intensive and wider development of prospecting operations in promising regions. This must be done, because, for example, in West and East Siberia the share of prospecting drilling by RSFSR Mingeo organizations today makes up less than a third of total penetration, which is clearly inadequate. In other words, instead of building a broad beachhead for a new assault on behalf of the oil and gas producers, we spent our main efforts here on consolidating positions already won.

Right now the new "Classification of the Reserves of Oil and Fuel-Gas Fields" is being compiled. Geologists and specialists of the State Commission for Reserves of Useful Minerals under the USSR Council of Ministers (USSR GKZ) have proposed that this classification include a statement according to which exploration of oil and gas deposits by USSR Mingeo organizations should be considered complete when recoverable reserves comprise 70-75 percent and prospective reserves make up the other 25-30 percent. However, Minnefteprom [Ministry of Petroleum Industry] representatives have been "studying" this question for 2 years now. In our view, the time has come when the country's planning organs and USSR GKZ should show more persistence in speeding up the issuance of this program document for geologists.

It must be noted that no few possibilities exist for improving planning and the organization of the job, not just at the interindustry level. For production associations and oil petroleum exploration expeditions of USSR Mingeo, the correct choice of criteria for evaluating their activity is of considerable significance. Right now the main evaluative indicator for these organizations' work, aside from growth of recoverable-category reserves, is the total amount of penetration and the number of holes whose construction has been completed, which reflect extremely closely the final goal: to obtain reliable geological information. Obviously, an evaluation of the step-by-step fulfillment of geological tasks for amounts of prospecting drilling and the plan for growth both of recoverable and of prospective reserves would be more objective.

Probably it is time to be concerned also about raising the motivation of geologists to fulfill plans for prospecting drilling. Such a system of material incentives, which would compel that preference be given to the outstripping development of regional and prospecting operations, should be developed.

As for other reserves for speeding up the preparation of fuel and mineral raw-material reserves, the effectiveness of geological prospecting for oil and gas can be increased by reducing substantially the amounts of deep exploratory drilling in such regions that have few prospects and have been studied in detail as the Western Ukraine, the Crimea, Kaliningradskaya Oblast, the Belorussian SSR, Kirghizia, Tajikistan and other regions, with the consequent relocation of the labor and material and equipment resources that are released in these regions to new and promising regions.

This is why it will be desirable to insert the following editing into the geological portion of Part IV of the "Basic Directions": /Provide for accelerated development of the geological study of the country and an increase in the explored reserves of mineral raw materials, primarily fuel and energy resources, after having called for, in so doing, further improvement in the planning, organization and standard practices for conducting geological exploration."/

11409
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USE OF VOLGA DISTRICT SHALE AS FUEL URGED

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 11 Jan 81 p 2

[Article by F. Koval'skiy, chief geologist of Nizhnevolzhskgeologiya [Lower Volga Geological Association] (Saratov): "The Fuel Shale of the Volga Region"]

[Text] The draft of the "Basic Directions" poses the task of cutting the consumption of petroleum and petroleum products as boiler and furnace fuel. One of the real paths for accomplishing this task is the wider use of fuel shales in the European part of the USSR, where shortages of other fuel and energy resources are making themselves felt increasingly appreciably.

Geological studies of recent years have recommended that the shale-bearing Volga Basin, which covers Kuybyshevskaya, Ul'yanovskaya, Saratovskaya and Orenburgskaya Oblasts, be included among the regions that are promising for industrial development, in addition to the previously known fields in Estonia and Leningrad Oblast. An area of 1,000 km^2 has already been studied by drill holes. According to preliminary data, the reserves of fuel shale in formations that are of industrial interest exceed 10 billion tons in these areas alone.

A study of Volga shale has shown that its heating value is high enough, but it does contain much sulfur. Therefore, maximum economic benefit can be achieved, provided that processing is waste-free, that is, with full utilization of both the organic and the mineral portion of the shale. And this task is fully feasible.

Industrial-test gasification of Volga shale has indicated the possibility of obtaining gas that is suitable for industrial and domestic consumption. Also studied was high-speed pyrolysis of pulverized shale, which enables gas, benzene, toluene, thiophene and sulfur to be obtained. The Institute of Fuel Minerals of the USSR Ministry of Coal Industry has conducted laboratory studies on the thermal dissolving of Volga shale with a view to obtaining synthetic liquid fuel, bitumens and other materials. Treatment of the liquid products of thermal dissolving will enable an energetic fuel of low sulfur content, raw material for gasoline, and so-called shale oil to be obtained.

But skeptics justify their position by the fact that industry still is not ready to accept practical introduction of the scheme proposed by the scientists. It seems to us that the single correct conclusion from the situation that has been created should be an intensification of both scientific research and experimental design work with a view to solving fully all the engineering questions. For thermal dissolving, which enables asphalt and low-sulfur fuel to be obtained, is one of the promising areas for the use of rock shale.

At present less than 1 million tons of shale are obtained per year at the Kashpirskoye field. The main customer is the Syzran' TETs. As we see, the scale of mining does not begin to compare with the basin's reserves.

Meanwhile, technical and economic calculations confirm the high level of profitability of organizing a large industry here for mining and processing the shale. In particular, such enterprises can be erected in Saratovskaya and Kuybyshevskaya Oblasts. Introducing the fields of fuel shale into operation in the near term will give a powerful push to further development of the region's chemical industry and to an expansion of the variety of products produced.

It is necessary to be engaged in earnest with the problems of the integrated use of fuel shale, which are of an interagency nature. The scientific, design and design-development organizations that have been called upon by reason of their activity to solve this problem, have been subordinated to different ministries--Minenergo [Ministry of Power and Electrification], Minugleprom [Ministry of Coal Industry], Minneftekhimprom [Ministry of Petroleum Refining and Petrochemical Industry] and Minpromstroymaterialov [Ministry of Construction Materials Industry]. Need it be said that this fragmenting does not do the business any good? The best method of speeding up the work would be the establishment in Saratov of a special scientific-research institute, following the example of NIISlanets [Scientific-Research Institute for Shale] in the city of Kokhtla-Yarve, Estonian SSR.

/Drawing the shale of the Volga region into economic circulation will be of great importance in improving the country's fuel and power potential. Therefore, I propose to include this task in the "Basic Directions": "Speed up the preparation of a new mineral raw-materials base for fuel shale of the Volga." [in boldface]/

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RECENT PROGRESS, CURRENT PROBLEMS AT KOMI OIL, GAS FIELDS TOLD

Moscow PRAVDA in Russian 3 Feb 81 p 1

[Article by A. Kurkov (Ukhta, Komi ASSR): "From the Arctic's Depths"]

> [Text] Part X of the CPSU Central Committee's draft for the 26th party congress said: "...continue development of the fuel and power complex in the Komi ASSR." Much is concealed in this line. A large coal-mining industry has been established in the autonomous republic, and power engineering is being developed rapidly. Nevertheless, the oil and gas industry of this district, which is rich in natural resources, has the paramount role. That is what this is all about.

...After easily leaving the concrete strip of the Ukhta airport, the airplane heads north. On the flight to Arctic Usinsk, the twilight is lit up by chains of fires.

During the 10th Five-Year Plan more than 250,000 m^2 of housing, kindergartens and nurseries have been built and a construction-industry base has been established in Usinsk, which has become the center of a new administrative rayon of the Komi ASSR. Right now three-fourths of the local liquid fuel is being recovered from the depths of Arctic deposits--the Usinsk and neighboring Vozey fields. Well, the difficulties are well-known here: a lack of roads and permafrost.

During the 10th Five-Year Plan oilfield workers produced 67.5 million tons of liquid fuel. In volume of annual growth in oil recovery, the Komi ASSR is in second place in the country, after West Siberia. During the last 5 years more than 1 billion rubles have been invested in developing this industry--2.2-fold more than during the Ninth Five-Year Plan.

Komineft' [Komi ASSR Oil Industry Association] General Director A. Gumenyuk says:

"During the current five-year plan we will have to increase oil recovery by a fourth. Already at the start of the five-year plan the amounts of well-drilling must be brought up to 1 million meters per year. Development of deposits that are located beyond the Arctic circle will commence: Khar'yaginskoye, Grubosherskoye and Severo-Vozey, which have already been explored. Hundreds of kilometers of roads, power lines and oil and gas pipelines will have to be laid there. Each year 40,000-50,000 square meters of housing and facilities for social, cultural and everyday-living purposes are to be built, and a base for auxiliary agriculture is to be established."

It is important to note that the casing-head gas of the northern fields, which runs through the recently built installations of the Usinsk gas-treatment plant, will go to the new Pechorskaya GRES, which is situated close by.

A. Gumenyuk named still another figure: by the day the 26th CPSU Congress opens the association's oilfield workers will have sent 12,000 extra tons of "black gold" to refineries.

Another important branch of the developing Komi ASSR fuel and power complex is gas recovery. Vuktyl is still the main region for obtaining the "blue fuel." In 1981-1985 it is planned to recover 84.3 billion m^3 of gas at this field. This is 9 billion m^3 less than was achieved during the 10th Five-Year Plan.

"This reduction is a natural process, for the field's natural resources are being gradually depleted," says I. Kharin, chief engineer of Komigazprom [Komi ASSR Gas Industry Association]. "So our paramount task is to stabilize gas recovery. It is planned to assimilate at the start of this five-year plan the new West-Soplesskoye gas-condensate field, which neighbors Vuktyl. It must be brought up to design capacity--2 billion m^3 per year--in 1985. But the main work will continue at the facilities of the chief storehouse--Vuktyl. Here the buildup of the field is being completed: 30 more producing wells are being drilled, and the total number of such wells will reach 150 by 1983."

The line from the CPSU Central Committee's draft that was quoted at the start of this article presupposes the exploration and discovery of new oil and gas fields.

"Work will be done in the Komi ASSR and in the southern portion of the Nenets Autonomous Okrug of Arkhangel'skaya Oblast in forthcoming years," says V. Khor'kov, general director of Ukhtaneftegazgeologiya [Ukhta Oil and Gas Geology Administration]. "The task of greatly increasing oil and gas reserves by 75 billion m^3 during this five-year plan has been set. For this purpose hundreds of thousands of meters of deep exploratory wells must be drilled."

And so a serious problem rises up here: in order to cope with this quantity, considering the complete lack of roads and the great dispersion of drill rigs, freight must be brought into the backwoods at an overwhelming pace. And for this purpose the dates for allocating materials and equipment must be changed: everything that is necessary for well penetration should arrive here during the winter, when the seasonal import of freight goes on over the winter roads that have been laid out in the taiga and the tundra.

Komi republic geological explorers are devoting much effort to building bases for drilling. They are building them by the in-house method in Vorkuta, Inta, Pechora and Usinsk, since not much hope is placed on contractor help. V. Khor'kov complains that Glavkomigazneftestroy [Main Administration for the Construction of Gas and Oil Industry Enterprises in the Komi ASSR]--the main contractor in Ukhta--has already missed three times the deadlines for completing the rebuilding of the base for outfitting structures at the derricks, where the explorers of the depths set mobile housing out for themselves. And without them there is no solution to the problem of housing in the backwoods.

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FUELS

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LIFE OF OIL-RECOVERY EQUIPMENT BETWEEN REPAIRS MUST BE LENGTHENED

Moscow NEFTYANOYE KHOZYAYSTVO in Russian No 1, 1981 pp 3-7

[Article by A. A. Dzhavadyan and Ya. Ya. Shkadov (Minnefteprom [Ministry of Oil Industry]): "Certain Questions About Developing Oil-Recovery Equipment During the 11th Five-Year Plan"]

[Text] Development of the oil industry during the 10th Five-Year Plan, the same as in preceding years, was accompanied by constant and often substantial complication of drilling-geology conditions for the fields being developed. Ever-larger fields have had to be developed in severe natural and climatic zones, factors that cannot help but exert a major influence on the nature of decisions about operating techniques and equipment. In the forthcoming period, the complication of conditions for development will continue, the more so because in the oil-bearing regions more fields that contain highly viscous and sulfurous crude or which are represented by poorly delineated reservoirs will be drawn into operation. Naturally, this will also affect the nature of the decisions about operating techniques and equipment.

But the most important circumstance, which cannot be ignored in plans for scientific and technical development of the oil industry, will be the consistent change in operating conditions at fields that are entering the late stage of development, this being the largest group, from which a major share of the country's total oil recovery has been obtained. Also making themselves felt here to a significant degree are a progressive increase in the water encroachment of wells, aging of the wells, a reduction in productivity, increasing aggressiveness of the output, intense deposition of salts and paraffins, and natural wear of the metal equipment. Because of this, the amount of work associated with maintaining well productivity and with insuring the reliability of operation of the oilfields' operating facilities is constantly growing. In these circumstances, in order to avoid losses of recovery and to prevent unjustified production outlays, one cannot restrict oneself just to solving the problems that arise at a given moment. Unfortunately, certain enterprise supervisors and leading production specialists often commit such mistakes. One must foresee the possible changes in operating conditions, consider them, and subordinate the solution of current problems to them.

Let us examine some of the more important questions of developing equipment for oil recovery.

Let us dwell first of all on changes in structure of the well inventory by method of operation. At present the inventory of operating wells is made up of: flowing wells 14.7 percent, those operated by electrical centrifugal pumping installations (UETsN) 18.9 percent, those operated by bottom-hole rod pumps (ShGN) 63.2 percent, and gaslift wells 2.8 percent. During 1970-1979 the number of wells being operated by mechanized methods increased 1.46-fold, wells operated by ShGN 1.3-fold, gaslift wells 1.15-fold and UETsN-equipped wells 2.7-fold.

Thus the share of wells operated by highly productive equipment has risen, occasioning the necessity for boosted withdrawal of liquid. The average liquid withdrawal from wells operated by UETsN's was 4,113 tons per pumped well per month in 1979 (1.3-fold higher than in 1970). During later five-year plans the share of mechanized oil recovery has risen constantly in West Siberia, although highly productive wells are put into operation here each year.

The greatest change in the structure of recovery by operating methods has proved to be intensification in the development of wells of the Urals-Volga region, as a result of which a large number of wells were converted to the mechanized method of recovery. Thus, in Tataria their number increased from 60 percent to 99.2 percent from 1970 through 1979. The absolute amounts of mechanized recovery in Tataria rose by 46 percent during this period, in Kuybyshevskaya Oblast by 59 percent, and in West Siberia 122-fold, while for Minnefteprom it rose 1.75-fold when the total amount of recovery increased 1.6-fold.

With the increase in the well inventory operated by the mechanized method, the amount of work has increased for their repair and servicing (table 1). It is evident from table 1 that, despite a certain reduction during the decade in the frequency of current repair per well, the absolute number of repairs increased by almost 16,000. Frequency of repair was reduced by executing a set of organizational and technical measures and making certain improvements in equipment design, but it is still extraordinarily high. At the same time, given the existing state of supply, there are substantial reserves here.

Table 1

Indicator	1970	1975	1979
Average number of industrial-production personnel for oil recovery, thousands of persons	104.3	108.8	163.8
Number of repairs, thousands:			
Overhaul	12.0	16.5	20.0
Current repair	221.0	229.7	228.8
Frequency of current repair of wells, repair/well per yr:			
Flowing wells	0.46	0.46	0.41
Gaslift wells	1.00	1.04	1.89
Wells with UETsN [electrical centrifugal pumping installations]	3.46	2.00	2.05
Wells with ShGN [bottom-hole rod pumps]	5.13	4.70	4.03
Number of wells converted to mechanized recovery	1,648	2,265	3,546

The problem of reducing considerably the frequency of current repair becomes exceptionally urgent during the 11th Five-Year Plan because of the expected further change in the structure of recovery by operating method and the contemplated substantial growth of the well inventory. The plans for scientific and technical measures must consider that even in 1980 a period of reduced recovery had started at many oilfields that had gone to maximum recovery. The development of most fields will be complicated primarily by the fact that as poorly productive fields are brought into operation and the well network density is increased somewhat, the operating inventory will be greatly increased (table 2).

Table 2

Number of operating wells	Minnefteprom		West Siberia	
	On 1 Jan 81	On 1 Jan 86	On 1 Jan 81	On 1 Jan 86
Total......................................	82,477	122,445	12,156	35,886
Flowing wells................................	11,431	14,361	7,002	10,258
Wells with UETsN [centrifugal electrical pumping installations]......................	17,221	34,100	3,190	13,407
Wells with ShGN [bottom-hole rod pumps]......	51,525	67,734	1,499	7,896
Gaslift wells................................	2,300	5,950	465	4,025
Wells with GPN [hydraulic piston pumps]......	-	300	-	300

Water encroachment of the product of the wells also is increasing. While for the industry as a whole in 1970, 0.8 m^3 of water was removed per 1 ton of oil, it is assumed that water removed will reach 1.38 and 1.91 m^3/ton in, respectively, 1980 and 1985. This will require an increase in the average productivity of the technical means for raising liquids from the wells.

A substantial reduction in the share of recovery of crude by the flowing method also should be expected. The share of mechanized recovery with highly productive equipment will increase correspondingly. Moreover, the conditions of well operation will be made complicated by bringing into development fields with oil reserves that are not easily accessible and that are low in value.

Thus, as calculations indicate, during the 11th Five-Year Plan the inventory of mechanized wells will increase 1.5-fold, of which 89 percent will be pumped wells. In so doing, the structure of the mechanized inventory (see table 2) is planned on the basis of the actually expected potential for production of the equipment, although wide development of the gaslift method and the use of hydraulic piston pumps (GPN) would be more effective. An optimal structure for recovery should be formulated by methods based upon the main technical and economic indicators shown in table 3, but this is seriously restricted by the potential for producing the equipment, especially for gaslift operation, which is more effective, particularly for West Siberian regions.

Table 3

Method of operation	Period between repairs, days	No. of repairs per year per 1,000 wells	No. of repair brigades per 1,000 wells	Time for a repair, hours	Specific manning by NGDU* industrial-production personnel per well of the operating inventory
Gaslift.....	2,000	182	1	44	0.3
UETsN**.....	232	1,573	10	44	2.0
ShGN#.......	148	2,466	7	18	2.0
GPN##.......	2,000	182	1	40	0.3

*Oil and gas recovery administration.
**Electrical centrifugal pumping installation.
#Bottom-hole rod pump.
##Hydraulic piston pump

Because of this, Minnefteprom, jointly with Minkhimmash [Ministry of Chemical and Petroleum Machine Building] have critically analyzed the question of expanding during the 11th Five-Year Plan the complex for producing gaslift equipment, and, based thereon, of increasing the amount of recovery by the gaslift method. At the same time it is planned to rebuild the gaslift-operation systems at the Kotur-Tepe and Barsa-Gel'mes fields in Turkmenia and the Uzen' and Zhetybay fields in Kazakhstan.

However, realization of the contemplated measures still will not enable gaslift operation to be expanded to the required scale, so UETsN eventually is to be introduced widely. During the 11th Five-Year Plan the share of UETsN in the total growth of the operating-well inventory is to be 42.2 percent, ShGN 40.5 percent. Consequently, during the forthcoming five-year plan the main measures for raising the effectiveness of operating methods is associated with improvement of UETsN and ShGN. The most important directions in this work will be to raise the technical level and quality of the production of equipment for UETsN and ShGN; to improve operating conditions for the use of this equipment; to execute a set of measures for correctly selecting equipment and establishing regimes for its operation; to strengthen existing services and to create new ones for the inspection and repair of pumping equipment; and to substantially improve the organization, equipment and technology for the current repair of wells.

The task of making better use of pumping equipment is complicated and it requires the joint participation of many NGDU [oil and gas-recovery administrations] and production-association services. At the same time, oilfield workers need effective assistance from the workers of scientific-research and design organizations.

Minnefteprom, together with a large group of subcontracting ministries, has worked out a comprehensive program of operations for the establishment of highly reliable UETsN's. In 1981 the production of UETsN's of improved design, based upon new materials and industrial methods of production, will commence, with a view to bringing the country's average operating period between repairs of the installations to 450 days.

Simultaneously, in accordance with the indicated work program, Minnefteprom is to take steps in 1981-1982 to improve operating conditions and to raise UETsN repair-work quality for the purpose of bringing the operating time between repairs for repaired wells up to 80 percent of the time between repairs for new installations. The importance of these measures is confirmed by the fact that in Tatneft' [Tatar ASSR Oil Industry Association] and Bashneft' [Bashkir ASSR Oil Industry Association], where repair has been better organized than in other associations, the periods between repairs for overhauled installations are, respectively, 62 and 75 percent. In counting on a decisive contribution by the machinebuilders to produce high-quality and reliable UETsN's, oil-recovery workers should not forget that the operation and repair of these installations cannot be recognized as satisfactory at many oilfields. Thus, during the first half of 1980, 10.7 percent of all the current repairs of wells equipped with UETsN were repeated because of low repair quality. In this case, the repeat repair work was 19.6 percent in Tomskneft' [Tomskaya Oblast Oil Industry Association], 18 percent in Glavtyumenneftegaz [Main Administration for the Tyumenskaya Oblast Oil and Gas Industry] and 15.4 percent in Kuybyshevneft' [Kuybyshevskaya Oblast Oil Industry Association].

Moreover, premature failures of UETsN's have been caused to a great extent by irregularities in the work of the installing and repair services, by mechanical damage to cable, incorrect choice of equipment, the lowering of unsealed hoists, and poor well completion. The quality of current repair of UETsN's is especially unfavorable in Nizhnevartovskneftegaz [Nizhnevartovsk Oil and Gas Industry Association] and Kuybyshevneft'.

There are still definite difficulties at the oilfields with respect to the servicing and repair of UETsN's, but the main cause of repeat repairs is inadequate attention to quality in the current repair of wells. Raising the quality of repair and servicing of UETsN's is a considerable reserve for oil recovery, as the positive experience of advanced brigades of many oil-industry enterprises will attest.

The solution of questions of raising the operational indicators for wells equipped with ShGN requires earnest attention. The share of oil recovered by this method is not great in comparison with recovery by UETsN, but 63.2 percent of the wells that have the shortest time between repairs and, consequently, the largest number of current repairs, are being operated by means of ShGN. Actually, time between repairs averages about 103 days for them, but for some associations it varies from 40 to 326 days. Despite the 12-day increase in well-operating time for ShGN wells between repairs during the Ninth Five-Year Plan, ShGN service life is inadequate. If this period is kept at the 1979 level until 1985, the number of repairs of ShGN-equipped wells will grow by 25.7 percent.

Work to insure high reliability for ShGN should be performed in two directions: raising the technical level and quality of rods and equipment, and improving operation of the equipment at the oilfields.

The first direction is a most important task for machinebuilding organizations. During 1970-1980 they did definite work to improve the quality of sucker rods, which are being manufactured with rolled threads and threaded grooves. The rods are being produced, but not in adequate amounts, from six varieties of high-quality steel, TVCh [high-frequency current] treatment being called for in the case of two of them. As a result, the number of twistoffs per well per year has been reduced to 0.20 to 0.58, whereas the average indicator is 0.72 for all types of rods used.

While rod quality has improved considerably, no qualitative changes have occurred in the field of rod-pump production. Unfortunately, as before, the plants produce the very same pump for all categories of wells, regardless of the complexity of their operation. The machinebuilders must speed up conversion to the large-scale output of new types of rod pumps, particularly of linerfree pumps with wear-resistant coating of the cylinder's inner surface. The types of rod pumps that are produced should meet diverse operating conditions, allowing selection of pumps precisely in accordance with the optimal regime for pumping liquid that is contemplated for each well.

Beam-pumping units should meet these same requirements. Instead of the 13 standard sizes called for by the GOST [All-Union State Standard] 5866-76, only 5 are being produced. The production of beam-pumping units designed for a load of 12 tons-force and a moving distance of 3.5 meters and of units without a walking beam that were developed long ago has not been mastered, and searches for new design solutions that will provide for higher efficiency and less metals intensiveness are not being made.

The tasks of developing the oil industry urgently require that machinebuilders solve these problems whose time has come during the 11th Five-Year Plan.

At the same time, oil-recovery enterprise workers should do daily painstaking work to improve ShGN well-operations technology. At enterprises where such work has been organized well and is being conducted at a high technical level, important results are being achieved. Work with the Bashneft' inventory of bottom-hole pump wells is an example.

Thus, in 1966 operating time between repairs for wells with ShGN was 82 days, but by 1979 this had increased to 260 days, while the inventory of such wells had risen from 4,050 to 9,500. The selection, reporting and monitoring of rods and rod strings has been skillfully organized here; this has enabled a reduction in the average number of twistoffs of rods from 1.7 to 0.36 per well per year, and, correspondingly, a reduction in the number of current repairs for eliminating rod twistoffs from 6,000 to 3,230, although the wells with ShGN had increased by 5,450. As a result, in 15 years the number of current-repair brigades had increased altogether by 21, while the operating-well inventory had increased by more than 7,500. Thus, the experience of Bashkir oilfield workers indicates that it is possible to get better results with the use of serially produced equipment, so in 1981 oilfield workers of other areas must study and introduce this new experience more widely.

Together with increases in the productivity and reliability of the oil-lifting equipment, the problem of improving and developing methods for intensifying the inflow of oil into the well will be no less important during the forthcoming period. In addition to an increase in the recovery potential of wells, the use of these methods will enable an increase in the recovery factor; this, unfortunately, is not always considered in oilfield development practice.

During 1978-1980 about 38,000 operations for intensifying inflow, or about 1 per 6 wells per year, were performed. However, such measures are carried out mainly at fields that are in late stages of development. Not by far is inflow intensification viewed as a reserve for additional oil recovery and as a means for increasing withdrawal at any stage of development. At the same time, operations to stimulate the bottom-hole zone often are performed with technological irregularities, and the choice of stimulation methods is not adequately substantiated.

Collectives of Glavtyumenneftegaz, Tatneft', Bashneft', Grozneft' [Groznyy Oil Industry Association], Komineft' [Komi ASSR Oil Industry Association] and Udmurtneft' [Udmurt ASSR Oil Industry Association] have achieved good indicators in this field. Working in close contact with regional NII's [scientific-research institutes] and insuring a skilled engineering approach to the selection of the wells and to the technology of stimulation, they have been able to obtain from each operating well an average of 740 tons of additional oil, whereas the industrywide average is 200 tons.

This article has treated only certain problems that are more important for oil recovery and are directly connected with the effective operation of producing wells. No less important are problems of improving oilfield systems for treating oil, gas and water and insuring their reliability and economy; further improving and developing automation systems and equipment for the repair and servicing of wells and operating facilities; and developing effective methods for the drive against deposits of paraffin and mineral salts and also against corrosion in wells and the corrosion of equipment.

All these problems occupy an important place in plans for scientific and technical development during the 11th Five-Year Plan. As before, special attention must be paid to more complete use of casing-head gas. Most oil-producing regions have brought the utilization level thereof up to 85-95 percent of the resources. However, in some associations the gas utilization situation remains unsatisfactory and requires the adoption of more energetic measures. The Minnefteprom board in June 1980 examined questions of more complete use of gas and approved urgent measures in this area.

Oil-producing enterprise workers rely on the help of NII's in solving scientific and technical problems that have matured. During the 10th Five-Year Plan the industry's scientific workers took an active part in overcoming technical difficulties that arose. Solved mainly with their help was the problem of the drive against salt deposition (BashNIPIneft' [Bashkir ASSR State Scientific-Research and Design Institute for the Oil Industry] and SibNIINP [Siberian Scientific-Research Institute for Oil Production]), foam systems are being used successfully in certain technological processes of recovery (VNII [All-Union Oil and Gas Scientific-Research Institute]), work has been done to improve oil-treatment quality (VNIISPTneft' [All-Union Scientific-Research Institute for Preparation of Oil for Pipeline Transport]), and so on.

The scientific potential of the industry's NII's will also enable other urgent problems to be coped with successfully, primarily those problems that are important for successful work by oilfield workers during the forthcoming five-year plan. Unfortunately, many NII's are carrying out developments extremely slowly. Thus, PermNIPIneft' [Permskaya Oblast Scientific-Research and Design Institute for the Oil Industry] and UkrgiproNIIneft' have been working for a long time on designs for linear electric drives for bottom-hole pumps, but there have been no results yet. Work to create a hydraulic impulse pump (UkrgiproNIIneft'), a heat pump (VNII) and various types of gas and gas-and-sand anchors (AzNIPIneft' [Azerbaijan SSR Scientific-Research and Design Institute of the Oil Industry]) has been drawn out. The OKB BN has been slow to improve submerged screw pumps (although they are being produced in series), and the periods for producing many promising developments are being extended intolerably. Some NII's go for many years without proposing any kind of basically new solutions in the equipment and technology for recovering oil.

Successful solution of the questions raised will in the next 10 years open up real promise for cutting the requirement for servicing and repair personnel at oil-producing enterprises by 25,000 and savings in operating costs that will exceed 3-fold to 3.5-fold the requirement for funds for developing the corresponding machinebuilding capacity.

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FUELS

FUTURE TASKS FOR UKRAINE'S COAL MINING INDUSTRY DESCRIBED

Kiev UGOL' UKRAINY in Russian No 1, Jan 81 pp 1-4

[Article by N. K. Grin'ko, UkSSR Ministry of Coal Industry: "On Entering the New Five-Year Plan"; passages enclosed in slantlines printed in boldface]

[Excerpts] As was the case during the preceding plan period, the party and the government are paying great attention to development of the fuel and power complex, one of the key branches of which is the coal industry. Coal, one of the main sources of power, heat and light, participates directly in many spheres of production and serves as an important foundation for further raising the people's welfare.

During the 10th Five-Year Plan the republic's miners gave the national economy more than 1 billion tons of fuel. The mines were furnished with better equipment. The levels of mining by longwall-mining machines and excavation by cutter-loaders and of the conveyorization of transport rose. The work done to build new mines and to rebuild existing ones increased 1.3-fold over the Ninth Five-Year Plan. Capital investment in the amount of 5.4 billion rubles was assimilated. The mines imeni Stakhanov, Voroshilovgradskaya No 1, Novomirgorodskaya, No 10 Velikomostovskaya, Zhdanovskaya-Kapital'naya, imeni Geroi Kosmosa, imeni Leninskiy Komsomol Ukrainy, Nagol'chanskaya No 1/2 and Sukhodol'skaya-Vostochnaya were put into operation. A number of mines were rebuilt. Two hundred and sixty-five galleries were built, 70 shafts and holes were driven, and 300 fans for the main ventilation systems and 310 elevating machines were replaced. The amount of excavation for striping and preparing a line for the breakage faces increased.

In giving credit for what has been achieved, the party shows great solicitude for tomorrow's power engineering as a most important branch of the national economy. The task consists in improving the fuel and power balance in the 1980's. /A most important element in solving this task is the execution of measures for building up the capacity of the mines, preparation plants and machinebuilding plants, and for reequipping and improving the inventory of mines, giving consideration to the peculiarities and the dynamic development of the republic's coal regions./ Significantly, much more capital investment is to be directed toward this purpose during the 11th Five-Year Plan than during the preceding plan.

Implementing the huge and complicated tasks that face the industry's workers during the 11th Five-Year Plan requires a high state of organization and discipline and increased responsibility at all levels of supervision of the coal industry--from the ministry to the mines and to the sections. This is why the ministry's staff and the supervisors of associations and mines should constantly monitor strictly the fulfillment of each item of the integrated program for developing the industry during 1981-1985 and up to 1990 and should fulfill the state plan, from the first days of the new five-year plan.

In October 1980 the Politburo of the Central Committee of the Ukrainian Communist Party heard the report of the republic's Ministry of Coal Industry, correctly criticized the deficiencies, and gravely required that the level of supervision of the branch be raised and that urgent measures for correcting the situation be executed. Unsatisfactory work of the coal industry in recent years has been complicated by reason of the slow introduction and assimilation of the capacity of new mines and rebuilt mines and by inadequately effective use of mining equipment. Many mines do not pay due attention to preparatory operations, and idle time occurs because of breakdowns of machines and mechanisms and violations of labor and production discipline. Some association and mine collectives have not coped with the plans, falling short by large amounts of coal.

Our deficiencies are the result mainly of oversights in organizational work. Under the prevailing tense situation in coal mining, administrations of the ministry, the associations and the mines have not found those forms and methods of operation that would counter the negative phenomena that cause reductions in the indicators.

/V. I. Lenin pointed out that it is impossible to teach people to solve their tasks with today's new methods if we have not opened our eyes to yesterday's experience./ The industry's workers should take lessons from the past.

Strenuous plans for the amount of coal mined have been established for 1981 and the 11th Five-Year Plan. In order to cope with this amount of work, it is necessary to seek out additional reserves and to produce 43,000 tons more of coal per day than in 1980. This is a complicated task. As L. I. Brezhnev noted at the October 1980 CPSU Central Committee Plenum, /"It is necessary to support the plan tasks by precise organizing activity, high discipline and rigid control."/ With a view to strengthening operating discipline and to raising responsibility at all levels of the ministry, a program was worked out that calls for:

- At mines--to sum up monthly the results of work to prepare and introduce breakage faces, to make equipment available and to utilize it, and to utilize workers of the main vocations with a view to guiding all efforts toward an increase in the mining of coal;

- At associations--to examine quarterly fulfillment of the mine development program, the plan for capital construction and for balance in the provisioning of materials and equipment, and the plan for the integrated development of miners' settlements, towns and cities; and

- At the ministry--to monitor strictly the fulfillment of party and government decrees and in-house decisions, the use and development of the mine-inventory capacity, the creation, testing and introduction of mining equipment, planning of the use of advanced experience, and improvement of quality of the coal and of other technical indicators.

The development and use of the repair base, equipment and materials, labor and financial resources, improvement of the style and methods of work, and improvement of management have been taken under unremitting monitoring. At the center of attention is the organization of socialist competition and questions of personal-amenity services, cultural facilities, shopping and social eating. A specific program has been directed toward the most rapid elimination of deficiencies and the unconditional fulfillment of decisions of the Politburo of the Central Committee of the Ukrainian Communist Party and of engineering and technical measures for carrying out the 1981 plan.

The decisions of the October 1980 CPSU Central Committee Plenum and the October 1980 Plenum of the Central Committee of the Ukrainian Communist Party paid great attention to the construction of housing and cultural and personal-amenity facilities. This was reflected in the plans of the republic's coal industry for 1981. Capital investment for the construction of housing, schools, hospitals and kindergartens grew 13.2 percent over 1980, including 12.1 percent for construction and installing work. Consequently, 1 million m^2 of housing space will be introduced (132,000 m^2 more than in 1980), and twice as many schools and kindergartens and four times as many hospitals will be introduced as in 1980.

In 1981 it will be necessary to assimilate 1.744 billion rubles of capital investment (including 537.7 million rubles more for construction and installing work), to introduce 4 million tons of capacity for mining coal (3.75 million tons from new mines and 250,000 tons from rebuilt mines) and to complete the construction and introduce 53 galleries at existing mines, 5 shafts, 15 large-diameter holes and 34 fans for main ventilation systems and 8 cooling installations. Minebuilders must speed up the development of their own production base, accelerate excavation work, especially in the construction of vertical shafts, and man construction projects with workers of the leading trades. The requirements laid down and the responsibilities placed on clients (production associations) for completely supplying construction workers on time with good-quality design and budget-estimating documentation and on scientific-research and design institutions for the substantiation of recommendations and suggestions, especially about workloads at breakage faces, should be increased.

Timely and good-quality reproduction of the breakage front and the status of underground transport exert a great influence on rhythmic mine operation. The construction of new galleries and the modernization of underground transport schemes, the elimination of a multiplicity of stages in transport, and an increase in the reliability and throughput of transport elements are most important operations here. In using advanced experience for seeking out reserves, it is contemplated to increase the number of thousandeer brigades and the number of high-speed tunneling brigades. Each association and mine should have a special plan for introducing the achievements of science, technology and innovators' suggestions that are borrowed from sources of scientific and technical information and from the experience of the best brigades, sections and mines.

/The main prerequisites for increasing effectiveness of the industry's work are acceleration of the pace of reequipping the mines, the creation and wide introduction of equipment that will provide for integrated mechanization of coal in thin seams and cutter-loaders for making preparatory excavations in hard rock, and mechanization and automation of the main and auxiliary production processes./ Meanwhile, there are deficiencies and difficulties in reequipping mines, but there is a way out from the situation that has been created, for example at thin seams. The "Donbass," KMK (standard size 1), KM-88 and KM-103 cutter loaders have passed tests successfully. Their timely production must be arranged. This relates also to other types of underground mining equipment, the creation and production of which have slackened. It should be said that coal-machinery manufacturing plants--the Druzhkovka Plant imeni 50-Letiya Sovetskoy Ukrainy, the Gorlovka Plant imeni Kirov, Kharkov's Svet Shakhtera and Elektromashina plants and a number of other enterprises--are not fulfilling their commitments to the miners and are failing to deliver equipment and spare parts.

/In order to carry out successfully the tasks that the industry faces, work with personnel must be improved decisively./ New workers are coming into the industry. The Komsomol Central Committee of the Ukraine and oblast, city and rayon Komsomol organizations, which are implementing the call, "The coal faces need youth!" are extending great practical assistance. Attributing exceptionally great importance to raising the role of Komsomol organizations in coal-industry development, a decision has been adopted in accordance with which the Komsomol-Youth detachment Stakhanovets is sending 4,000 people to coal enterprises that are in operation or under construction. The supervisors of mines and construction projects should take a careful and attentive attitude toward youth augmentation and furnish the prerequisites for highly productive labor by them and for their recreation.

Thus the main tasks for improving the coal industry during the 11th Five-Year Plan are:

- An accelerated buildup of the capacity of the mine inventory;
- An increase in the pace of further requipping the mines; and
- Execution of the program for training, selecting and assigning personnel.

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MORE USEFUL ANALYSIS OF COAL ENTERPRISES' WAGE STRUCTURE URGED

Kiev UGOL' UKRAINY in Russian No 1, Jan 81 pp 17-19

[Article by A. G. Chirakh, chief economist of the hydraulic mine Krasnoarmeyskaya of the Dobropol'yeugol' [Dobropol'ye Coal Association]: "An Analysis of the Structure of the Average Wage of Coal Enterprise Workers"]

[Text] In the nature of a suggestion.

The average pay of coal-enterprise workers is the basic indicator that chacterizes the wage level. Deviations from average pay affect the saving or overexpenditure of the wage fund and the prime cost per ton of coal. Therefore, a detailed analysis of the dynamics of average pay will enable a study of the factors that affect its level, will reveal their positive or negative influence and deficiencies in the organization of workers' wages, and will prevent overexpenditure of the wage fund.

A comparison of the average pay level during reporting and plan periods and also during the corresponding period of the previous year will enable the dynamics of average pay to be established for later analysis of the relationships of the rates of growth of labor productivity and of pay. At present no scheme or procedure for analyzing average pay has been worked out. A detailed analysis is a necessity not only to a mine's economic service but also to the board of an association when wages are compared by mine. The planning and economic section of an association needs the data of such an analysis for the first 9 months of the year when it plans the indicators for the next year's work.

Statistical report forms (2T, No 9 and No 32) that are made up by the mine's economic services do not reflect the structure of average pay by category of worker or of industrial-production personnel as a whole. For example, the form No 32 (part I) shows the actual pay of blue-collar workers by production process for the reporting period for the time worked without making a comparison with the plan or with the corresponding period of the preceding year. Part IV of Form No 32 reflects the actual pay-fund structure by type of wage for blue-collar workers for mining coal in a comparison with the plan, but the data on total amount of the pay fund does not describe the level of the workers' wages, since the manpower for one and the same size wage fund is different in most cases. Form No 9 reflects the absolute amount and an index of the average blue-collar worker's wage for mining coal and of industrial-production workers in comparison with the plan and with the corresponding period of the preceding year. Approximate information about average monthly pay, which can be obtained from the data of this form, is shown in table 1, which indicates that the level of average pay for industrial-production workers is reduced in comparison with the plan and with the corresponding period of the previous year by, respectively, 12.6 rubles (4.5 percent) and 29.1 rubles (9.7 percent), while the reduction for blue-collar workers and white-collar workers was greater. The level of average pay for engineers and technicians was even raised in comparison with the plan by 7.5 rubles (2.7 percent), but in comparison with the corresponding period of last year it was reduced by 45.6 rubles (13.7 percent). It is not clear from the cited data which factors caused the absolute and relative deviations in average pay for the worker categories.

In order to establish the cause of the change in average pay for the reporting period, its structure should be analyzed. Use of the element-by-element method of analysis is desirable for this purpose. Its essence consists in breaking down average pay by component elements (pay under piecework rates, wage rates, bonuses, additional payments, and so on), according to which deviations of the indicators from those planned and from those achieved during the preceding period are determined, and then, if necessary, the causes of the deviations are discovered by additional analysis.

When analyzing average pay it is necessary:

to discover the dynamics of the share of disbursement from the wage fund and from the material-incentive fund for basic categories of workers and for industrial-production personnel as a whole;

to analyze the structure of average pay for the worker categories named;

to establish the elements of disbursement that caused the changes in the pay level of the main categories of workers and their quantitative effect on absolute and relative deviations;

to determine the effect of changes in average pay of the various categories of workers on the overall changes of average pay of industrial-production personnel;

to disclose the causes of the deviations and to outline possible measures for eliminating negative factors and to make use of positive factors.

Planning and reporting data from parts I, III and IV of form No 9 and from parts III, IV and VII of form No 32, plus additional information taken from reports of the mine's standards-setting section, are used to analyze the structure of average pay of workers.

It is known that the full average monthly pay of the worker is made up of parts that are paid out from the wage fund and disbursed from the material-incentive fund. In making the analysis, the full pay of a worker is taken as 100 percent, and then the share of the component parts in the total pay is determined by dividing the share of pay from the various sources in accordance with the formulas

$$T_1 = 100Z_{z.p.}/Z_a; \text{ and} \qquad (1)$$

$$T_2 = 100Z_{m.p.}/Z_a,$$

Table 1

Indicators	Actual, for corresponding period of last year	The reporting period: Plan	Actual	% of the plan	% of corresponding period of last year	Deviation from: The plan	Corresponding period of last year
Average monthly pay of industrial production personnel, rubles	299.5	283.0	270.4	95.5	90.3	-12.6	-29.1
Blue-collar workers	302.8	289.8	273.3	94.3	90.3	-16.5	-29.5
Engineers and technicians	333.7	280.6	288.1	102.7	86.3	+7.5	-45.6
White-collar workers	150.6	157.3	133.7	85.0	88.8	-23.6	-16.9

where $Z_{z.p.}$ and $Z_{m.p.}$ are the amounts of pay of a worker from, respectively, the wage fund and the material-incentive fund, in rubles; and

Z_a is the absolute amount of the full average monthly pay of a worker, in rubles;

Pay is further broken down under the principle "from the large to the small," that is, each component part of the pay is apportioned by basic element. The share of the average pay of a worker by element of disbursement from the wage fund and the material incentive fund is computed according to the formula

$$Z_{\text{э.в}i} = \Phi_{\text{э.в}i}/Ch, \qquad (2)$$

where $\Phi_{\text{э.в}i}$ is the amount of the wage fund or material incentive fund for the worker category being analyzed for the i-th element of disbursement, in rubles; and

Ch is the average monthly manning of the worker category being analyzed, for the base, plan or reporting periods.

The share of the period of pay for the constituent elements of disbursements in overall pay is computed according to the formula:

$$T_1 = 100Z_{\text{э.в}i}/Z_a. \qquad (3)$$

In order to facilitate the computations and to show the clarity of the detailed element-by-element analysis of the structure of average pay, an analytical table of a unified form is made up for all worker categories. The table includes data on the amount of average pay by fund and by element of disbursement, their share in the overall average pay, the absolute deviations from the plan and from the report for the preceding year, and also the quantitative effect of the absolute deviations by element of disbursement on the overall change of the average pay of the workers.

In determining the quantitative effect (in percent) of the absolute deviations of the share of pay by element of disbursement on the relative change $V_{\text{э.в}i}$ of the full pay of the worker category being analyzed for the reporting period in comparison with the report for the preceding year, the following formula is used:

$$B_{\text{э.в}i} = \pm 100\ Z_{\text{э.в}i}/Z_a, \qquad (4)$$

where $\Delta Y_{з \cdot Bi}$ are the positive (+) or negative (-) absolute deviations of the share of the pay for the i-th element of disbursement in comparison with the plan or the report for the preceding year.

In so doing, the sum of the absolute and relative deviations in pay by disbursement element should equal the sum of the deviations of the component parts and of the wage fund as a whole. Because the shares of manning of blue-collar workers and engineers and technicians and of their pay comprise 95-98 percent of total manning and of the wage fund of industrial-production personnel, an element-by-element analysis of the structure of average pay is performed for these two categories of workers and for industrial-production personnel.

The analytical tables 2 and 3 show an approximate element-by-element analysis of the pay of blue-collar workers for mining coal and of industrial-production personnel as a whole. Pay has been broken down in consolidated form in order to reduce the size of the tables. In the mine environment, this breakdown is performed in more detail. The amounts of pay under piecework rates and bonuses must be broken down by production process (extraction, preparatory and other operations) in order to reveal the effect of the preparatory operations on change in pay.

Pay for blue-collar workers, engineers and technicians is broken down under a unified principle, that is, by constituent element, but it is somewhat different for industrial-production personnel, that is, this pay is broken down first by the component funds of the categories of workers, and then by fund element within the worker categories. This scheme of analysis enables the effect of the elements of the funds for various worker categories and for the fund as a whole for this worker category on the absolute and relative changes in pay for industrial-production worker to be found.

In comparing the rate of growth of labor productivity and average pay under existing methodologies, the index of average calculated pay is used at the mines. It is analyzed similarly, with increased bonuses for carrying out additional coal-mining tasks being excluded from the full pay. Exclusion of the bonuses presupposes the existence of comparable indicators for comparable conditions. When making an analysis of pay, attention must be paid to additional payments for work on off-days. In economic content, the indicated pay affects the growth of full average pay, as is the case with a bonus for an additional task for mining coal. But the influence of this factor in determining calculated pay is not considered under the existing methodology, yet this must be done because of a number of circumstances. While the work plan does call partially for additional pay for work on off-days, in the report it can differ significantly from the plan because of deviations in the days of work. Such deviations can be observed also when comparing them with reporting data for the corresponding period of the preceding year. In order to obtain objective results when analyzing the rate of growth of pay, the effect of additional payments for work on off-days must be excluded as an unproductive factor in an increase in pay that is connected with temporary difficulties in the mine's operation. Moreover, additional pay for work on off-days occupies a greater share in the structure of the average wage than the bonus for doing additional tasks, especially at mines that are not meeting the plan for mining coal per workday.

In the economics literature and in the case of associations, rates of growth for labor productivity and average pay are compared with the corresponding period of the preceding year, while in the case of the mine they are compared with the plan.

Table 2

No.	Elements of the blue-collar workers' fund	Actual for corresponding period of last year	Reporting period being analyzed, (rubles)		Deviation of report data (+ increase, - decrease) (rubles) from		Effect of deviation (in %) of pay by element on total change of pay in comparison with	
			Plan	Report	The plan	Last yr's report	The plan	Last year's report
	Average pay of blue-collar workers for mining (total).................	302.8	289.8	273.3	-16.5	-29.5	-5.7	-9.7
1	From the wage fund.................	296.4	284.5	268.9	-15.6	-27.5	-5.4	-9.1
1.1	Under piecework rates............	104.4	111.8	102.0	-9.8	-2.4	-3.4	-0.8
1.2	Under wage (salary) schedules.....	67.6	65.6	65.6	0	-2.0	0	-0.7
1.3	Bonuses...........................	62.7	46.8	37.7	-9.1	-25.0	-3.1	-8.2
1.3.1	For fulfilling the plan.........	35.2	46.8	21.0	-25.8	-14.2	-8.9	-4.7
1.3.2	For overfulfilling the plan.....	20.0	U	13.0	+13	-7.0	+4.5	-2.3
1.3.3	For fulfilling additional tasks.	7.5	U	3.7	+3.7	-3.8	+1.3	-1.2
1.4	Additional payments included in the daily fund.......................	28.0	25.6	30.3	+4.7	+2.3	+1.6	+0.8
1.4.1	For work on holidays and days off.	14.5	12.8	13.1	+0.3	-1.4	+0.1	-0.5
1.4.2	Not exceeding the average earning or the schedule..................	4.0	2.1	7.2	+5.1	+3.2	+1.7	+1.1
1.4.3	Others............................	9.5	10.7	10.0	-0.7	+0.5	-0.2	+0.2
	Total by element of the daily fund..	262.7	249.8	235.6	-14.2	-27.1	-4.9	-8.9
1.5	Additional payments included in the monthly fund......................	33.7	34.7	33.3	-1.4	-0.4	-0.5	-0.2
1.5.1	For regular and additional leaves.	27.5	29.7	28.8	-0.9	+1.3	-0.3	+0.4
1.5.2	Others............................	6.2	5.0	4.5	-0.5	-1.7	-0.2	-0.6
2	From the material incentive fund....	6.4	5.3	4.4	-0.9	-2.0	-0.3	-0.6

Note: U is an unplanned element of the fund and of the average pay.

Table 3

Номер (1)	Элементы фонда по источникам и категориям работников (2)	Факт. за соотв. период прошлого года (3)		Анализируемый отчетный период (4)				Отклонения отчетных данных (+ повышение, − снижение) (7)				Влияние отклонений (%) зарплаты по элементам на общее изменение ее по сравнению (10)	
				План (5)		Отчет (6)		от плана (8)		(9) от отчета прошлого года			
		Размер, руб. (11)	Уд. вес, % (12)	Размер, руб. (11)	Уд. вес, % (12)	Размер, руб. (11)	Уд. вес, % (12)	по размеру, руб. (13)	по уд. весу, % (14)	по размеру, руб. (13)	по уд. весу, % (14)	с планом (15)	с отч. прошл. года (16)
	(17) I. Удельный вес источников в общей средней заработной плате ППП												
	(18) Среднемесячная заработная плата (всего)	299,5	100,0	283,0	100,0	270,4	100,0	−12,6	0	−29,1	0	−4,5	−9,7
1	(19) Из фонда зарплаты	284,1	94,9	272,7	96,4	262,4	97,0	−10,3	+0,6	−21,7	+2,1	−3,6	−7,2
2	(20) Из фонда материального поощрения	15,4	5,1	10,3	3,6	8,0	3,0	−2,3	−0,6	−7,4	−2,1	−0,8	−2,5
	(21) II. Удельный вес фондов категорий работников в общей средней заработной плате ППП												
1	(22) За счет фондов рабочих	253,5	84,6	243,6	86,1	228,8	84,6	−14,8	−1,5	−24,7	0	−5,2	−8,2
1.1	(23) В т. ч. из фонда зарплаты	248,1	82,8	239,2	84,5	225,1	83,3	−14,1	−1,2	−23,0	+0,5	−5,0	−7,6
1.1.1	(24) Из него по сдельным расценкам и тарифным ставкам (окладам)	144,0	48,0	149,2	52,7	140,3	51,9	−8,9	−0,8	−3,7	+3,9	−3,1	−1,2
1.1.2	(25) премии (всего)	52,4	17,5	39,4	13,9	31,6	11,7	−7,8	−2,2	−20,8	−5,8	−2,8	−6,9
1.1.3	(26) по остальным элементам	51,7	17,3	50,6	17,9	53,2	19,7	+2,6	+1,8	+1,5	+2,4	+0,9	+0,5
1.2	(20) Из фонда материального поощрения	5,4	1,8	4,4	1,6	3,7	1,3	−0,7	−0,3	−1,7	−0,5	−0,2	−0,6
2	(27) За счет фондов ИТР	39,2	13,1	33,3	11,8	33,4	12,3	+0,1	+0,5	−5,8	−0,8	0	−1,9
2.1	(23) В т. ч. из фонда зарплаты	29,8	9,9	28,1	10,0	29,2	10,7	+1,1	+0,7	−0,6	+0,8	+0,4	−0,2
2.2	(20) из фонда материального поощрения	9,4	3,2	5,3	1,8	4,2	1,6	−1,1	−0,2	−5,2	−1,6	−0,4	−1,7
	(28) Из него премии по положениям текущего премирования	8,1	2,7	4,1	1,4	3,4	1,3	−0,7	−0,1	−4,7	+0,7	−0,2	−1,6
3	(29) За счет фондов прочих категорий работников	6,8	2,3	6,1	2,1	8,2	3,0	+2,1	+0,9	+1,4	+0,7	+0,7	+0,4
3.1	(23) В т. ч. из фонда зарплаты	6,5	2,2	5,6	1,9	8,1	3,0	+2,5	+1,1	+1,6	+0,8	+0,9	+0,5
3.2	(20) из фонда материального поощрения	0,3	0,1	0,5	0,2	0,1	—	−0,4	−0,2	−0,2	−0,1	−0,2	−0,1

1. Number.
2. Fund elements by source and worker category.
3. Actual, for the corresponding period of last year.
4. The reporting period being analyzed.
5. The plan.
6. The report.
7. Deviations of the reported data (+ increase, - decrease).
8. From the plan.
9. From the report for last year.

[Key continued]

Table 3 (continued)

Key:

10. Effect of the deviations (in percent) of pay by element on total change of pay in comparison.
11. Amount, rubles.
12. Share, percent.
13. By amount, rubles.
14. By share, percent.
15. With the plan.
16. With last year's report.
17. I. Share of the sources in the total average wage PPP [industrial production personnel].
18. Average monthly pay (total).
19. From the wage fund.
20. From the material incentive fund.
21. II. Share of the funds of the categories of workers in the total average pay of PPP.
22. Through funds of the workers.
23. Including those from the wage fund.
24. Of this amount, according to piecework rates and wage (or salary) schedules.
25. Bonuses (total).
26. For other elements.
27. Through funds for ITR's [engineers and technicians].
28. Of which, bonuses in accordance with the rules for current awarding of bonuses.
29. Through funds for other categories of workers.

A comparison of the growth of these indicators in a comparison with the plan can be nonobjective in nature. Various deviations in the wage fund and in average pay for workers from the calculated indicators occur in the work plan. If the fund has been planned with a reserve, then the pay planned is overstated. This leads to a distortion of the actual rate of growth of pay, with the corresponding consequences. In our opinion, it is inconsistent to make distinctions between associations and the production units that comprise them in matters of establishing bases for comparison when analyzing rates of growth of pay and labor productivity. Despite the difference in levels, the principles for analyzing growth of these indicators should be uniform.

/Conclusions./ The explanatory memorandum for an analysis of the production and financial-management activity of a mine for the quarter or the year should contain an element-by-element analysis of the structure of average pay of the worker in order to establish the effect of various factors on change of one of the main economic indicators. In analyzing the structure of average calculated pay, the effect of additional payments for work on days off and holidays must be excluded in the plan and in the report.

In analyzing rates of growth of average pay and output per industrial-production worker for a reporting period, the comparison should be made with the reporting data for the corresponding period of the previous year, not with the plan, as is now being done.

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